RESEARCH ARTICLE

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The Role of Technology and Social Media Use in Human Papillomavirus Awareness: A Comparison Across Four Age Groups

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Abstract

Background: Human papillomavirus (HPV) is a significant public health crisis across various age groups. While technology and social media are crucial for disseminating health information, their potential remains underutilized due to varying levels of familiarity and comfort with digital platforms among different age groups. This study examines whether using technology and social media for health-related purposes predicts HPV awareness across different age demographics in the United States. **Method:** This cross-sectional study employed two datasets from the National Cancer Institute's Health Information National Trends Survey (HINTS 5, Cycle 1, and Cycle 2, from 2017 and 2018). The datasets were merged and analyzed, with a sample size of 6,789. Weighted binary logistic regression analyses were performed across age groups to evaluate how technology and social media use for health purposes predicted HPV awareness. **Results:** The analysis revealed that the use of technology for health-related purposes was associated with higher HPV awareness across all age groups: 18-34 years, 35-49 years, 50-64 years, and 65 years and older. Conversely, social media use for health information was significantly associated with increased HPV awareness only among younger adults (18-34 years). **Conclusions:** This study highlights the need to effectively integrate technology and social media to enhance HPV awareness among both younger and older adults with age variations. Leveraging these platforms for behavioral health interventions could promote better health practices and increase HPV awareness across all age groups.

Keywords: Human papillomavirus (HPV)- Awareness- Technology- Social media, Age groups

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Introduction

Human Papilloma Virus (HPV) refers to a group of over 150 related types of a DNA tumor virus that causes abnormal growth and accumulation of epithelial tissue in the skin and mucous membranes [1, 2]. Globally, HPV accounts for 90% of all cervical cancer, 70% of vulvar and vaginal cancers, 90% of anal cancers, and 60% of penile cancer cases [1]. In the United States (U.S.), HPV infection remains one of the most ubiquitous sexually transmitted infections (STIs), with an estimated 34,800 cases of HPV are reported annually [1, 3]. As of 2023, in the U.S., an estimated 42 million persons are infected with a disease-causing genital HPV type, with approximately 13 million persons being newly infected each year, the majority of whom are in their late teens or early twenties [1, 4, 5]. Studies show that nearly all sexually active men and women between 18 and 59 years old will contract the HPV virus at some point in their lives, especially if not vaccinated, and the infection can lead to the development of genital warts and cancers [1, 6, 7]. Although HPV is generally benign, it imposes significant social, psychological, and economic burdens on both patients and society as a whole [8].

Although HPV infection is a well-known serious public health crisis[9], there is still much lower levels of awareness for both younger and older adults in the general population [10, 11]. While HPV prevention through vaccination can only be done in the early years (previously until 26, and more recently 45), awareness about it, especially among older generations, such as caregivers for adolescents or young adults can bring about preventative actions for their children [12, 13]. For instance, prior cross-national studies conducted in the Netherlands and the U.S. that examined HPV awareness in parents with children and adolescents aged 8 to 17 years found that parents who were aware of HPV encouraged and initiated their children to get vaccinated and followed up to ensure that their children had access to HPV information [14, 15]. It has been recommended that increasing awareness of HPV among adults could prevent more than 59% of HPV infection-related cases [3, 16]. HPV awareness is unwaveringly essential when making informed health-related decisions. However, lack of HPV awareness can

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lead to ambivalent attitudes that can be easily malleable and may contribute to difficulties in making good health decisions [17, 18].

In the U.S., national rates of HPV-related awareness have continued to decline, highlighting the need for innovative population-level interventions to enhance HPV awareness [19, 20]. This may also require integrating health information technology (HIT) to influence HPV-related awareness and improve vaccine adoption positively [21]. Modern technology continues to improve the ability to communicate and enhance efficiency in accessing health information in nearly all aspects of human lives [22, 23], including HPV cases [21]. People of varying ages who access health information through technology are more likely to be aware of HPV and available vaccines and are at lower risk of becoming infected with HPV [24]. Interestingly, even older adults who are 50 years and above who may be reluctant to use technology, and especially those living with compromised health status, may be taking advantage of the internet and other available technologies to access information for healthcare purposes [25-27]. Nonetheless, more younger people than older adults are actively engaged in digital health technology use to access vital health information related to HPV awareness [28, 29], and that can lead to making informed health decisions in their lives and further prevents the risks associated with HPV [30].

Regardless of one's age, technological use provides endless opportunities through the daily web, email, and mobile technology such as texting and encouraging positive behavior change regarding HPV [31, 32]. The most common technologies used for accessing health information, including HPV, are smartphones (98.9%), mobile apps for tracking health information (65.5%), and text messages from their healthcare providers (29.3%) [33]. The advantages of using technology include reminders through text messaging and apps that helps to reduce missed appointments, educate young people about sexual health, and track patient information [33]. Most importantly, the widespread use of text messaging could help to reach diverse populations, as they draw more attention than email reminders [34, 35]. Hence, the use of digital health technology has been a cost-effective way to increase HPV awareness and knowledge, removing barriers, and increase vaccine uptake, especially for younger people who are at increased risk of HPV [2, 33].

Social media platforms are often the first resource for accessing health information [26, 36]. Numerous studies revealed that many people turn to social media to seek answers for their lingering health related questions, engage in discussions about HPV infections, and share information about HPV with others [7, 37-44]. More than 70% of U.S adults report using at least one social media site, including YouTube (73%) and Facebook (68%), making social media the most common source of important health information [45]. Simultaneously, increased social media use among older adults has been associated with increased HPV awareness [46]. However, utilizing social media has been found to be higher among younger people compared to older adults [32, 35, 47, 48]. In the U.S. alone, younger people (18 to 29 years) reported using one or more types of social media [49], such as YouTube (94%), Facebook (80%), Snapchat (78%), Instagram (71%), and Twitter (45%) [45]. As such, social media use is now one of the most important technology resource essential for assessing health information and breaking down communication barriers about essential health information related to HPV awareness, prevention, and vaccines for many people regardless of their age differences [50]. Despite the insurmountable benefits offered, social media can also be the source of potential misinformation that discourages people from accessing critical health information [51-53].

More so, although social media and technology are widely used as essential tools of promulgating multifaceted vital health information, including HPV awareness, previous studies have primarily focused on gender, race, ethnicity, and education when examining HPV awareness [54]. In addition, prior studies have primarily focused on providing vaccines, prevention, and interventions for HPV, but without considering how technology and social media use can play an informed role in promoting robust HPV awareness across age groups. Therefore, the purpose of this study is to examine whether the use of technology and social media for health-related purposes is associated with HPV awareness across different age groups (18-34 yrs., 35-49 yrs., 50-64 yrs., and 65 or older) in the U.S. The primary research questions this study endeavors to answer are outlined below:

1. In what ways do individuals in different ages vary in their health-related technology and social media use?

2. How does the association between the use of technology and social media for health-related purposes and HPV awareness differ across different age groups?

This study will provide essential baseline information for developing and implementing tailored digital interventions that can effectively engage patients in varying age groups to improve HPV awareness and eventually vaccination to reduce eminent risk.

Materials and Methods

Data Source

A cross-sectional research design was used in the present study, utilizing a secondary dataset from the National Cancer Institute's (NCI) Health Information National Trends Survey (HINTS). To increase the sample size of each age group, two cross-sectional datasets HINTS 5, Cycle 1, and Cycle 2 were merged and analyzed (total N = 6,789). Data from Cycle 1 and Cycle 2 were collected through self-administered mailed surveys between January 2017 and May 2018 to investigate the American public's use of cancer-related information. A two-stage stratified random sampling strategy was employed to ensure representativeness: first, a stratified sample of residential addresses was randomly selected from a comprehensive national file, and second, one adult was randomly chosen within each sampled household. The stratification in the first stage aimed to ensure that various demographic and geographic segments of the population were represented, thereby increasing the precision and generalizability of the findings. The final

sample size of 6,789 individuals across different age groups thus reflects a nationally representative, weighted sample of U.S. adults. Consequently, sample weights were not re-applied in this analysis because the merged dataset retained the weighted, representative nature of the original HINTS samples. More details regarding data collection for HINTS 5, Cycle 1 and Cycle 2, including sample size calculations and response rates, are reported in the respective methodology reports (National Cancer Institute, 2017, 2018).

Dependent and Independent Variables

The dependent variable, HPV awareness, was measured by asking respondents in HINTS 5 if they had ever heard of HPV (Human Papillomavirus). It was explicitly noted that HPV is not HIV, HSV, or herpes. Responses were coded as 0 for "no" and 1 for "yes."

The independent variables in our study were technology use and social media use. To measure technology use for health-related purposes, participants were asked in HINTS 5 if they had used a computer, smartphone, or other electronic means to do any of the following in the past 12 months (no=0, yes=1): (a) looked for health or medical information for themselves; (b) looked for health or medical information for someone else; (c) bought medicine or vitamins online; (d) used email or the Internet to communicate with a doctor or a doctor's office; (e) tracked health care charges and costs; and (f) looked up medical test results. The sum of these six items provided a continuous score for the level of technology use for health-related purposes, ranging from 0 to 6.

Social media use was another independent variable assessed in this study. Defined in HINTS as "using the Internet to connect with other people online through social networks like Facebook or Twitter," participants were asked if they had used the Internet in the past 12 months (no=0, yes=1) for the following purposes: (a) visiting a social networking site (e.g., Facebook or LinkedIn); (b) sharing health information on social networking sites (e.g., Facebook or Twitter); (c) writing in an online diary or blog; (d) participating in an online forum or support group for people with a similar health or medical issue; and (e) watching a health-related video on YouTube. For this study, two variables were analyzed: general social media use (including items a and c) and social media use for health (including items b, d, and e). The level of general social media use and social media use for health was calculated by summing the scores for each category and analyzed as continuous variables (general social media use: range 0–2; social media use for health: range 0–3).

Covariates

Sociodemographic characteristics, health care resources, English proficiency, self-reported health status, and family cancer history were included in the analysis as covariates. Most sociodemographic characteristics were classified as dichotomous variables, including gender (0 = male, 1 = female), marital status (0 = never married or other, 1 = married or living as married), educational attainment (0 = less than bachelor's degree, 1 = bachelor's degree or higher), and rural or urban residence (0 = rural, 1 = urban). Household income was divided into three groups: 0 for $0–$19,999, 1 for $20,000–$74,999, and 2 for more than $75,000. Health care resources were measured using two dichotomous covariates: health insurance coverage (0 = no, 1 = yes) and the frequency of visiting health care providers (0 = 0 times, 1 = 1–3 times, 2 = more than 4 times). Family cancer history was also measured as a dichotomous variable (0 = no, 1 = yes).

Statistical Analysis

With the final sample weight, population estimates were obtained for the independent variable and other covariates across four age groups (18–34 years old, 35–49 years old, 50–64 years old, and above 65 years old). To account for the complex survey design and ensure accurate variance estimates, 100 jackknife replicate weights were applied. These replicate weights represent systematically resampled subsets of the data, where each replicate omits a portion of the sample to mimic the variability of the full population. By calculating the estimates (such as HPV awareness proportions or regression coefficients) separately for each replicate and then analyzing the variation across them, we obtained robust and reliable standard errors that account for stratification, clustering, and unequal selection probabilities in the survey. Lastly, weighted binary logistic regression analyses were conducted across all age groups to predict the significant association between the variables and HPV awareness. All statistical analyses were performed using STATA/SE 15.1.

Results

Descriptive characteristics of the participants

Descriptive information of participants is presented in Table 1. About half of the participants were female (50.99%), married or living as married (53.87%). Around two-thirds of participants were non-Hispanic White (65.23%). Less than one-third of participants had a bachelor's degree or above (32.14%). More than forty percent of participants (44.71%) reported that their household income was between $20,000 and $74,999, while 37.77% reported having more than $75,000. Regarding healthcare resources, most respondents visited healthcare providers at least 1 time in the past 12 months (51.42% reported 1 to 3 times while 30.39% reported more than 4 times), and most participants had health insurance (91.60%). In addition, about three-quarters of participants reported having a family member who had cancer (74.49%). A significant difference in socio-demographic characteristics was found across four age groups: 18-34 years old, 35-49 years old, 50-64 years old, and over 65 years old ($p<0.001$).

Use of Technology and Social Media by Age Groups

Table 1 also presented the levels of HPV awareness and technology use for health-related purposes among participants across different age groups. Overall, respondents had a moderate level of HPV awareness with 62.37% responding that they heard of HPV. Older participants tended to have lower HPV awareness levels than their younger counterparts ($p<0.001$). Participants

Table 1. Socio-Demographics of the Sample (N = 6,789[a])

Variables	Total N (%)	18-34 years %	35-49 years %	50-64 years %	65 or older %	P-Value[b]
Gender						
Male	2564 (49.01)	47.67	51.35	51.31	44.46	<0.001
Female	3697 (50.99)	52.33	48.65	48.69	55.54	
Urbanicity						
Rural	926 (13.93)	10.35	11.73	16.44	17.75	<0.001
Urban	5863 (86.07)	89.65	88.27	83.56	82.25	
Race/Ethnicity						
Others	2938 (34.77)	40.09	41.3	32.31	20.41	<0.001
Non-Hispanic White	3851 (65.23)	59.91	58.7	67.69	79.59	
Marital Status						
Never married or other	3117 (46.13)	71.44	36.51	37.51	42.9	<0.001
Married or living as married	3498 (53.87)	28.56	63.49	62.49	57.1	
Education						
Below bachelor's degree	3720 (67.86)	60.01	63.24	71.22	77.29	<0.001
Bachelor's degree or above	2914 (32.14)	39.99	36.76	28.78	22.71	
Housing income						
$0-$19,999	1138 (17.53)	18.8	13.63	17.07	21.75	<0.001
$20,000-$74,999	2738 (44.71)	49.03	39.92	39.8	55.02	
$75,000 or more	2173 (37.77)	32.17	46.45	43.13	23.23	
Frequency going healthcare provider						
None	969 (18.19)	23.11	20.61	16.98	9.62	<0.001
1-3 times	3375 (51.42)	50.44	54.94	50.62	49.1	
4 times and above	2363 (30.39)	26.45	24.45	32.41	41.28	
Health Inusrance						
No	276 (8.40)	12.69	10.69	7.73	1.28	<0.001
Yes	5343 (91.60)	87.31	89.31	92.27	98.72	
Family cancer history						
No	1451 (25.51)	27.74	27.16	23.72	23.93	<0.001
Yes	4715 (74.49)	72.26	72.84	76.28	76.07	
HPV awareness						
No	2612 (37.63)	27.33	27.35	41.27	56.63	<0.001
Yes	4084 (62.37)	72.67	72.65	58.73	43.37	
	Total Mean	18-34 years Mean	35-49 years Mean	50-64 years Mean	50-64 Mean	P-Value
Technology use for Health-Related Purpose (range:0-6)	2.55	2.87	2.9	2.52	1.77	<0.001
Social Media Use for health (range: 0-3)	0.53	0.76	0.67	0.45	0.21	<0.001
General Social Media Use (0-2)	1.28	1.74	1.52	1.14	0.62	<0.001

[a]The total sample size of each variable may not be the same as the total sample size of the study due to missing values. [b]Pearson Chi-Square p-values for categorical variables and F-test p-values for Technology use for health purpose

reported a low level of using technology for health-related purposes (mean=2.55, range from 0 to 6). Compared to younger respondents, older respondents showed lower use of technology for health-related purposes (p<0.001). Participants reported a high level of using general social media (mean=1.28, ranging from 0-2) but a low level of using social media for health: 0.53 out of 3. Compared to younger respondents, older respondents showed lower use of general social media and social media for health (p<0.001).

Table 2 lists specific use of technology for health-related purposes. More than half of the participants had used electronics to look for health or medical information for themselves (71.09%) or someone else (58.99%). Around one-third of respondents had used electronics to communicate with a doctor or a doctor's office (35.56%),

Table 2. The Levels of Tehcnology Use for Health Purpose Across Age Groups

Variables	Yes N (%)	18-34 years %	35-49 years %	50-64 years %	65 years or older %	P-Value
Looked for health or medical information for yourself	4523 (71.09)	83.96	79.44	67.38	49.65	<0.001
Looked for health or medical information for someone else	3611 (58.99)	67.8	69.84	56.71	36.23	<0.001
Bought medicine or vitamins online	1540 (22.03)	21.7	24.17	22.77	18.09	<0.001
Used e-mail or the Internet to communicate with a doctor or a doctor's office	2401 (35.56)	38.72	41.22	35.11	24.22	<0.001
Tracked health care charges and costs	2106 (32.74)	39.5	36.17	32.67	19.69	
Looked up medical test results	2338 (33.37)	33.03	36.72	34.62	26.89	<0.001

track health care charges and costs (32.74%), or look up medical test results (33.74%). However, only around one-quarter of respondents reported using electronics to buy medicine or vitamins online (22.03%). Overall, older participants tended to have lower use of electronics for each health-related purpose, except compared to participants between 18-34 years old, participants between 35-49 years old had a higher level of using electronics to look for health or medical information for someone else, buy medicine or vitamins online, use e-mail or the internet to communicate with a doctor or a doctor's office or look up medical test results.

Table 3 shows the specific use of social media. More than half of the participants reported that they had used the internet to visit a social networking site (68.45%). However, only 5.05% of participants reported using social media to write an online diary or blog. In terms of social media use for health, very few respondents had used the internet to share health information on social networking sites (14.51%) or to participate in an online forum or support group for people with similar health or medical issue (6.23%). On the other hand, around one-third of participants had used the internet to watch a health-related video on YouTube (32.73%). Older participants appeared to have lower use of social media compared to the younger population ($p<0.001$), except participants in 35-49 years old group who tended to report a higher level of using social media to participate in an online forum or support group for people with similar health or medical issue, compared to participants who were 18-34 years old.

Binary Logistic Regression

As seen in Table 4, after controlling for other covaries, technology use for health-related purposes was positively associated with the level of HPV awareness among all groups: 18-34 years old (OR=1.29, 95%CI=1.03-1.62), 35-49 years old (OR=1.35, 95%CI=1.12-1.64), 50-64 years old (OR=1.224, 95%CI=1.11-1.39), and above 65 years old (OR=1.27, 95%CI=1.12-1.44). However, social media use for health was significantly associated with HPV awareness only among the youngest group aged between 18 and 34 years old (OR=1.83, 95%CI=1.08-3.10). In contrast, general social media use was not associated with HPV awareness in any age group.

Among other covariates, female participants were more likely to be aware of HPV compared to males across three age groups: 35-49 years old (OR=3.16, 95%CI=1.96-5.09), 50-64 years old (OR=2.75, 95%CI=1.90-4.00), and above 65 years old (OR=2.14, 95%CI=1.47-3.11). Compared to other race/ethnicity, non-Hispanic White participants were more likely to have higher HPV awareness among middle-age to older groups: 35-49 years old (OR=1.75, 95%CI=1.08-2.84), 50-64 years old (OR=1.72, 95%CI=1.17-2.53), and above 65 years old (OR=1.53, 95%CI=1.00-2.34). Having a bachelor's degree or above was associated with a higher level of HPV awareness among two older age groups: 50-64 years old (OR=1.41, 95%CI=1.00-1.98), and above 65 years old (OR=1.47, 95%CI=1.04-2.08). Household income was significantly associated with HPV awareness level among the youngest groups (18-34 years old). Compared to participants with lower income ($0-$19,999), participants with medium household income ($20,000-$74,999) (OR=4.24, 95%CI=1.01-17.84) and high household income (OR=7.48, 95%CI=1.00-55.74) were more likely to have heard of HPV.

Table 3. The Levels of Social Media Use Across Age Groups

	Yes N(%)	18-34 years	35-49 years	50-64 years	65 years or older
General social media use					
To visit a social networking site, such as Facebook or LinkedIn	4213 (68.45)	88.16	78.02	65.84	39.39
To write in an online diary or blog (i.e., Web log)	242 (5.05)	9.51	7.22	1.94	1.34
Social media use for health					
To share health information on social networking sites, such as Facebook or Twitter	901 (14.51)	20.96	20.16	10.92	4.86
To participate in an online forum or support group for people with a similar health or medical issue	400 (6.23)	7.54	9.04	5.46	2.01
To watch a health-related video on YouTube	1938 (32.73)	49.47	37.17	29.27	13.99

Table 4. Binary Logistic Regression on Technology Use for Health-Related Purpose and Social Media Predicting HPV Awareness Across Age

Age	18-34 years	35-49 years	50-64 years	65 years or older
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gender (ref=Male)	1	1	1	1
Female	3.04 (0.91 - 10.13)	3.16(1.96 - 5.09)***	2.75(1.90 - 4.00)***	2.14(1.47 - 3.11)***
Rural/Urban (ref=Rural)	1	1	1	1
Urban	1.99 (0.67 - .94)	1.19 (0.50 - 2.81)	0.73 (0.47-1.14)	1.25 (0.75-2.07)
Race/Ethnicity (ref=Others)	1	1	1	1
Non-Hispanic White	1.31 (0.43 - 4.02)	1.75 (1.08-2.84)*	1.72 (1.17- 2.53)**	1.53 (1.00 - 2.34)*
Marital Status (ref= Never married or other)	1	1	1	1
Married or partnered	1.07 (0.35, 3.30)	1.14 (0.65 - 1.99)	0.98 (0.66 - 1.47)	1.06 (0.67 - 1.67)
Education (ref=Below bachelor's degree)	1	1	1	1
Bachelor's degree or above	2.63 (1.13, 6.11)*	1.52 (0.96, 2.40)	1.41 (1.00, 1.98)*	1.47 (1.04, 2.08)*
Household income (Ref=$0-$19,999)		1	1	1
$20,000 - $74,999	4.24 (1.01 - 17.84)*	1.01(0.48 - 2.14)	1.34 (0.71 - 1.78)	1.00 (0.62, 1.63)
$75,000 or more	7.48 (1.00 - 55.74)*	0.89 (0.41 - 1.95)	1.34 (0.74 -2.43)	1.13 (0.62 - 2.05)
Frequency of going to healthcare provider in the past 12 months (ref=0 times)	1	1	1	1
1-3 times	2.69 (0.86 - 8.46)	0.84 (0.46 - 1.52)	1.27 (0.77 - 2.09)	1.37 (0.67 - 2.79)
4 times and above	3.11 (0.58 - 16.75)	1.17 (0.55 - 2.47)	1. 19 (0.65 - 4.72)	1.22 (0.62, 2.43)
Health Insurance (ref=No)	1	1	1	1
Yes	0.95 (0.11- 8.05)	0.85 (0.33 - 2.18)	2.11 (0.94 - 4.72)	1.57 (0.22 - 11.22)
Family Cancer (ref=no)	1	1	1	1
Yes	2.37 (0.98 - 5.73)	1.44 (0.90 - 2.31)	1.29 (0.85 - 1.94)	1.20 (0.81 - 1.77)
Health related technology use	1.29 (1.03 - 1.62)*	1.35 (1.12, 1.64)**	1.24 (1.11 - 1.39)***	1.27 (1.12 - 1.44)***
Social media use	1.83 (1.08 - 3.10)*	1.06(0.74, 1.52)	1.05(0.80, 1.36)	1.01(0.73, 1.38)
General social media use	0.79 (0.27 - 2.26)	1.18 (0.72- 1.94)	1.23 (0.80 - 1.89)	1.39 (0.93 - 2.07)
N	627	1053	1603	1232
F-test	2.69**	7.51***	11.95***	6.52***
Hosmer and Lemeshow Test	0.48	0.63	0.25	0.25

p<0.05; ** p<0.01; *** p<0.00

Discussion

The primary purpose of this study was to examine the use of health-related technology and social media across different age groups, as well as to investigate the association between technology and social media use with HPV awareness across age groups in the U.S.

First, this study revealed an important generational divide in the use of technology and social media for health-related purposes, with older adults demonstrating lower use of both technology and social media relative to their younger individuals. This trend is consistent with existing literature that underscores the impact of age on technology adoption, particularly in the context of health management and information seeking [55-58]. Particularly, older adults often face insurmountable barriers to technology and social media utilization due to lower digital literacy, concerns about privacy, and general lack of confidence in using digital platforms [59]. These barriers further contribute to a reduced likelihood of engaging with health-related content online. For instance, studies have shown that older adults are less likely to own smartphones, use the internet, or engage with social media platforms, which limits their exposure to digital health interventions and information [60, 61]. This

demonstrated that lower use of technology and social media can have significant negative implications for their health outcomes, as access to digital health resources has been linked to disease prevention and improved health management [62]. Additionally, older adults may have different preferences when it comes to seeking health information. They tend to rely more on traditional sources such as print media, personal networks, and healthcare professionals, rather than seeking digital sources [63, 64]. Older adults' total dependence on traditional sources could be attributed to a higher level of mistrust in these sources, as well as their negative perception that digital information might be less reliable or harder to verify due to potential misinformation. The issue of trust is crucial, as older adults may be more skeptical about the credibility of online health information, which further discourages their use of technology and other social media platforms for seeking health-related information.

It is equally important understand that the general HPV awareness varies significantly across age groups, independent of technology or social media use. As evidenced in this study, older adults tend to have lower prevalence awareness of HPV, while younger individuals

were more likely to be well-informed about HPV. This trend aligns with findings from previous studies [24, 65]. An important explanation attributed for this difference could be that HPV awareness campaigns are primarily targeted toward younger individuals considered at risk of HPV infection, and may be eligible for the preventative vaccination, especially if they engage in unprotected sexual activity. In contrast, older adults, who may not be the focus of vaccination and awareness efforts, and may receive less information. Additionally, in the digital era, younger people are more likely to access health information through various technological and social media platforms, which older adults may be less inclined to use.

This study further demonstrates that technology use for health-related purposes was associated with higher levels of HPV awareness for individuals across all age groups. However, as individuals age, their levels of HPV awareness decrease as they relate to technology use for health-related information. This confirms previous research identifying older adults as passive consumers of health information, likely due to their limited use of technology [26]. This suggests that digital divide between older and younger adults may be large than expected, potentially limiting older individuals' access to health information, including HPV awareness. In contrast, younger people are more likely to use technology, such as smartphones and related mobile apps, that are constantly updated, thereby giving them an upper hand in accessing health-related information [28]. Some mobile apps could serve as valuable sources of health information, helping many young people access specific details about HPV. However, to address the widening digital divide between younger and older individuals, it is crucial to introduce effective mechanisms for designing age-appropriate educational interventions that encourage access to HPV information. Subsequently, promoting HPV awareness and knowledge and, if possible, immunization uptake can be implemented as part of rigorous efforts to increase HPV awareness [66]. Before current FDA recommendations, only people aged 9 to 26 were targeted for HPV vaccine uptake. As of 2018, the FDA expanded the use of the HPV vaccine to people aged 27 to 45 [67]. However, older adults are excluded, and therefore, most targeted health information is probably not directed toward them. This is especially possible on online platforms where information is presented to audiences through algorithms and other platform decisions. It is possible that some older adults might not have received formal safe sex education when they were younger [68]. This alludes to the importance of perceived susceptibility and severity of HPV to older adults. Older adults may be uncomfortable with seeking information on this topic. In that case, limited access or use of the internet and technology precludes them from being informed about the dangers of limited HPV awareness and knowledge. The advancement of technology provides insurmountable accessibility to computers, the internet, and smartphones for people of all ages. This can serve as a gateway to accessing HPV information at any time to those eager to learning about HPV [69]. Text messaging and smartphone applications (apps) are two most important current areas of technology that are often used to promote HPV awareness due to their popularity and highly accessibility to a broader audience [70]. The use of technology is evenly distributed across divisions of age, class, and international borders compared to other devices and services such as desktop and laptop computers and home broadband [70]. The strategic use of the internet, mobile phones, SMS text messages, and mobile apps helps to disseminate evidence-based HPV information [35]. These digital technologies will continue to advance, and new technologies and uses among older persons will likely emerge, holding great promise to promoting health information relating to HPV awareness [45]. In the coming years, integrating health-related technologies could become the mainstay of interventions that promote vaccination, knowledge, and awareness of HPV in many communities, institutions and organizations. These interventions could target all age groups since the risks of HPV are not only associated with younger people, but also older adults as they may be at risk due to limited knowledgeable. Therefore, implementing digital health technology can be cost-effective in increasing access to healthcare services and improve HPV awareness [33].

Furthermore, social media can be a strategic and successful tool for improving HPV awareness and other health information if used appropriately [33]. In the current study, social media use for health information was associated with greater HPV awareness only for individuals in younger age groups, which is consistent with previous studies [40, 47, 71]. The higher levels of social media use among these young adults may indicate where young adults access their information. In the case of older adults, our findings show that their awareness of HPV remains lower regarding social media use. As evidenced in the previous study, this could be explained by older adults' preference to use the internet primarily for email, with less than one-third using social media websites [72]. The strategic approach of providing informative health facts via a commonly used social media channel (i.e., Facebook) can be an educational strategy for improving young people's HPV awareness and knowledge. However, it may not be enough to move younger people toward behavior change to required to reduce the risk of HPV [7]. The rapid increase in the consumption of online health information offers both advantages (e.g., ease of access, reduction of common barriers to care such as stigma, transportation, and cost) and disadvantages (e.g., the potential for misinformation), especially for younger people [73]. Despite this, social media can be an effective, low-cost way of disseminating health information and motivating health behavior change [74].

In order to promote HPV awareness on social media, one must consider two distinct audiences: older adults and young adults [74]. Several groups have used social media to disseminate information about HPV awareness and the HPV vaccine efforts [7, 42, 75]. Despite the nearly ubiquitous presence of social media in the lives of many younger people, there is no clear consensus on how these platforms ultimately impact their levels of HPV awareness [45]. Social media campaigns can be developed to improve HPV awareness on a smaller scale. For example, a study

in Philadelphia of teenagers found that Facebook ads for sharing HPV-related health messages, including short-term consequences of HPV, such as genital warts, resulted in significantly higher views and likes than advertisements that included long-term outcomes, such as cancer [42]. Therefore, the role of Facebook in influencing HPV awareness cannot be underestimated and should be fully utilized as a reliable channel to communicate critical HPV information. Younger adults may desire health information campaigns focused on preventing immediate risks of HPV.

Limitations of the Study

The advantages of this present study include using HINTS data from different cycles that are considered representative of the national population with a large sample size that can be generalized. Despite this, the findings of this research must be viewed in the context of its limitations. This was a cross-sectional design; as such, we couldn't determine the causal relationship between HPV awareness and health-related technology use, as well as social media use for seeking health information. This study depended on self-reported data and, therefore, may lead to socially desirable responses on HPV awareness, health-related technology use, and social media use across all age groups. The binary questions, such as 'yes' or 'no,' used to measure technology use and social media use for health-related information never reflected the frequency of participants' technology and social media use for health-related purposes. There are limited studies that have investigated HPV awareness across the age groups; hence, the absence creates challenges to cross-reference. Finally, previous researchers have focused more on interventions and gender differences than exploring disparities in HPV awareness across different ages [14, 76, 77].

Implications for Health Practice and Policy

The lower use of technology and social media among older adults for health-related purposes presents a challenge for public health initiatives that increasingly rely on digital platforms to disseminate information and encourage healthy behaviors. There is a need for targeted interventions that bridge the digital divide observed across age groups. These include educational programs aimed at improving digital literacy among older adults, the development of user-friendly health apps tailored to the needs of this demographic, and initiatives to build trust in digital health platforms. Addressing the digital divide is about increasing access and ensuring that the content is relevant and accessible to older adults who appear to have insufficient HPV awareness. For instance, providing information in multiple formats, including audio and video, and ensuring that content is easy to navigate can help to improve digital health resources become more accessible.

Additionally, intergenerational initiatives where younger family members assist older adults in navigating technology could be beneficial as well. For instance, the delivery of HPV education to older adults needs to be re-evaluated since there appear to have limited understanding of HPV information at present. As such, increasing HPV awareness and knowledge can be used as a channel for empowering older adults to make informed choices regarding participation with HPV-related cancer prevention health strategies and support their children and family members who may be at risk of HPV. Older adults should also be encouraged to utilize technology to access health information about HPV. The availability of smartphones that includes access to the internet can be a source of enlightenment to reach higher levels of awareness they could have missed when they were younger regarding HPV-related health information. The most significant impact may be realized if these technology-based interventions are combined rather than used individually [35]. For instance, in a potentially ideal scenario, both younger and older adults can be informed of their risk associated with HPV by a post on Facebook or video on YouTube. In addition, the post may include scheduling appointments where the clinician would be prompted to give the HPV information via text message, email, or app to return to the clinic for the second dose of the HPV vaccine, and the patient would complete the vaccine series. This can be a source of increasing HPV awareness, especially for individuals who may not be using all the technological and social media platforms.

Equally important, attention should be directed towards promoting robust HPV awareness through technology and social media use during the early stages of life. Generally, many younger people are interested in receiving HPV information, along with other relevant health information. Through social media channels provided that messages are considered interesting, their privacy is protected, and the source is credible [7] . More so, HPV prevention through vaccination can only be done in the early years (previously until 26; and more recently 45) [13], so it is vital to target this age group. If social media is to be used as a successful vehicle to reach them, then this should be harnessed to reduce potential risk of HPV and improve awareness. At the same time, social media campaigns can be used to promote HPV awareness focusing on communicating clear, concise, and factually correct information to large numbers of both young and older adults at a lower cost. Specifically, HPV awareness campaigns should be used to communicate messages that can be tailored to the audience, and emphasizes on appealing to improving health behaviors [78]. Therefore, healthcare providers should be encouraging the use and exploration of various social media platforms such as Facebook or YouTube to empower young people in their healthcare decision-making required to improve HPV awareness [33].

Penultimately, there is a need to promote health education regarding HPV awareness, which can be achieved by fully taking advantage of technological platforms to advance this understanding across age groups. Social media-based efforts can also be utilized to increase knowledge of the benefits of HPV vaccination as cancer prevention, which may be a precursor to reducing HPV vaccine hesitancy and encouraging uptake to decrease HPV incidence rates, especially for younger adults at risk of HPV infection [46].

Finally, future studies should be directed toward a better understanding of how current technologies can

be used to promote, share, and influence health-related decision-making for older age groups who appear to have decreased levels of HPV awareness. Researchers should further examine HPV awareness by focusing on assessing protective factors and preventive interventions for younger adults and older at risk of HPV across age and gender differences. Finally, future studies should focus on education to further explore the discrepancies in HPV awareness among different age groups associated with social media and technology use.

In conclusion, this study has shown a generational gap in the use of technology and social media for health-related purposes, underscoring the need for inclusive health communication strategies that cater to the diverse needs of different age groups. Although technology and social media tools remain the preferred method of communication for disseminating health information, especially among younger people, they have not been fully adapted to promote robust HPV awareness. The variations in age significantly influence HPV awareness, with general awareness decreasing in each subsequent older age group as their use of technology and social media for health information declines. By understanding and addressing the barriers older adults face, we can improve their access to valuable health information and resources, ultimately contributing to better health outcomes regarding HPV awareness. Therefore, with their extensive features, technology and social media can be utilized as agents for positive behavior changes needed to achieve optimal health outcomes and advance awareness across variations of age groups for sexually transmitted diseases (STDs) and cancer-related infections such as HPV.

Author Contribution Statement

All authors contributed equally in this study.

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